

The Johns Hopkins University

Chemical Propulsion Information Agency

# Bulletin

Serving the Propulsion Community for Over Fifty Years

A DISA/DTIC-Sponsored DoD Information Analysis Center

Vol. 26, No. 3, May 2000

Distribution Unlimited

## The JHU Applied Physics Laboratory Continues a Long History of Propulsion Research

The Johns Hopkins University Applied Physics Laboratory (JHU/APL) has been involved with rocket and missile propulsion as a technology developer, as an evaluator of propulsion technology, and as a user of propulsion units for over fifty years. JHU/APL has been at the forefront of research and development in ramjet, scramjet, and mixed-cycle air-breathing propulsion systems since 1944, with the development and first successful flight test of a surface-launched, supersonic ramjet for the U.S. Navy. This leading edge high-speed air-breathing propulsion research continues today at APL with the development and evaluation of propulsion technology for the U.S. Navy Hypersonic Weapon Technology (HWT), the U.S. Air Force Hypersonic Technologies (HyTech), DARPA's Affordable Rapid Response Missile Demonstrator (ARRMD), and NASA's Access-To-Space [using Rocket-Based-Combined-Cycle (RBCC) propulsion] programs.

In parallel, JHU/APL has also maintained a longstanding expertise in systems engineering, in its role as a technical development agent for a variety of aerospace systems and military and civilian space systems, and has consequently sustained its capability to evaluate and to apply rocket propulsion technology to these systems. JHU/APL's sponsors include the U.S. Navy (NAVAIR, NAVSEA, SSP, and others), the U.S. Air Force, DARPA, and NASA. JHU/APL conducts various propulsion system analysis and evaluation tasks for U.S. Navy ship defense and tactical air-launched missile development programs.

JHU/APL's airbreathing propulsion efforts are led by Paul Waltrup, Dave Van Wie and Mike White in the Research and Technology Development Center (RTDC). JHU/APL is the lead organiza-

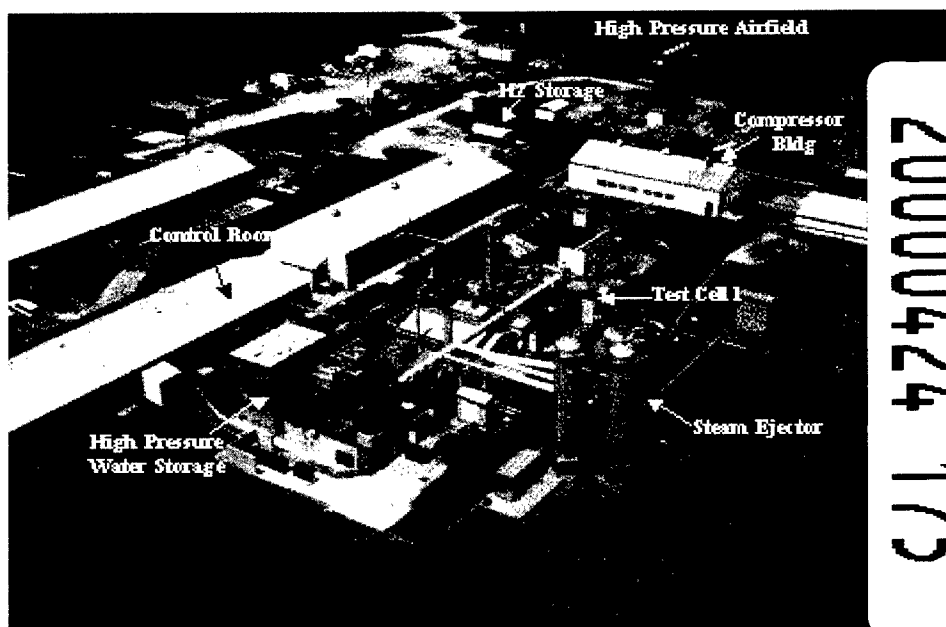


Figure 1. W. H. Avery Advanced Technology Development Laboratory

tion for propulsion technology development, integration and performance for the ONR Hypersonic Weapons Technology program. As part of this effort the APL is preparing for tests of advanced Dual-Combustor Ramjet (DCR) hardware under the guidance of Steve D'Alessio. For the ARRMD program, APL serves as the Lead Technical Advisor for DARPA, working closely with the Boeing-led industry team to develop a hypersonic cruise missile flight demonstrator. For the USAF HyTech program, JHU/APL is a technical advisor to the Air Force Research Lab program office. Led by Michael Thompson, APL is working closely with Pratt & Whitney on the testing of their HyTech engine concept. Finally, for NASA, JHU/APL is evaluating conceptual design and performance estimates for access-to-space vehicles powered by RBCC engines, evaluating RBCC experimental data and assessing optimum component performance. JHU/APL is also

working with Russian researchers at several Institutes and Universities to examine and develop advanced technologies applicable to scramjet engines and hypersonic fluid dynamics.

JHU/APL recently initiated several internal research and development (IRAD) projects to investigate fundamental aspects

*continued on page 4*

### Contents:

Meeting Reminders.....3

See AIAA Meeting Insert

CPIA Publications List.....2

CPIA Ti/Bi List.....2

Bulletin Board (Mtgs).....3

JANNAF (Mtgs).....back

## CPIA's Technical/ Bibliographic Inquiry Service

CPIA offers a variety of services to its subscribers, including responses to technical/bibliographic inquiries. Answers are usually provided within three working days, and take the form of telephoned, telefaxed, electronic or written technical summaries. Customers are provided with copies of JANNAF papers, excerpts from technical reports, bibliographies of pertinent literature, names of recognized experts, propellant/ingredient data sheets, computer program tapes and instructions, and/or theoretical performance calculations. The CPIA staff responds to nearly 800 inquiries per year from over 180 customer organizations. CPIA invites inquiries via telephone, fax, e-mail, or letter. For further information, please contact Tom Moore at (410) 992-7306, or e-mail: tmoore@jhu.edu. Representative recent inquiries include:

### Technical Inquiries

- RP-1 data and specification (TI1999112204).
- N-100 polyisocyanate properties and characterization (TI2000010306).
- Mechanical properties of CTPB propellants at low temperatures and various strain rates (TI2000022801).
- Rocket motors using tungsten nozzle throat inserts (TI12000022201).
- Use of silicone flexseals in rocket motors (TI2000022501).
- Aging and surveillance of Mk 12 Mod 1 Terrier propellants (TI2000030201).

### Bibliographic Inquiries

- 9DT-NIDA and ORP-2 energetic binders (BI2000012002).
- Lead-free propellant development (BI2000013102).
- Coating of solid propellant ingredients (BI2000013102).
- Secondary injection thrust vector control (BI2000020702).
- Engines using chlorine trifluoride and/or chlorine pentafluoride as oxidizers (BI2000010505).
- Ignitability and ignition testing of igniter materials and solid propellants (BI2000010506).
- Carbon-silicon carbide (C-SiC) use in missile applications (BI1999110501).
- Rocket engine recommended test practices (BI2000030202).
- High burning rate, high exponent solid propellant development (BI2000022301).
- Pressure measurements inside artillery guns (BI2000022302).



## TEP™ Put Some Combustion On Your Desktop

Point and Click Chemical Equilibrium Calculations

Six Built in Applications:

- Rocket Performance
- Gas Properties
- Detonation Wave Calculations
- Scramjet Performance
- Isentropic Path
- Shock Wave Calculations

Uses the NASA Equilibrium Program as the Compute Engine.

Thermodynamic Data Supplied

Just \$595. for a single user license, discounts for multiple licenses.

For more information contact:

SEA Software, Inc.

1802 N. Carson Street, Suite 200

Carson City, NV 89701-1230

e-mail: [doug@seainc.com](mailto:doug@seainc.com)

Telephone: (775) 882-1966 FAX: (775) 882-1827

Copyrighted by SEA Software, Inc. 2000

## Recent CPIA Publications

*CPTR-99-69, Burning Rates of  
Standard Solid Propellants for  
Gun Applications, September 1999.*

## CPIA Home Page <http://www.jhu.edu/~cpia/> Go There!

The Chemical Propulsion Information Agency (CPIA), a DoD Information Analysis Center, is sponsored and administratively managed by the Defense Technical Information Center (DTIC). CPIA is responsible for the acquisition, compilation, analysis, and dissemination of information and data relevant to chemical, electric, and nuclear propulsion technology. In addition, CPIA provides technical and administrative support to the Joint Army-Navy-NASA-Air Force (JANNAF) Inter-agency Propulsion Committee. The purpose of JANNAF is to solve propulsion problems, affect coordination of technical programs, and promote an exchange of technical information in the areas of missile, space, and gun propulsion technology. A fee commensurate with CPIA products and services is charged to subscribers, who must meet security and need-to-know requirements.

The *Bulletin* (circulation: 4,645) is published bimonthly and is available free of charge to the propulsion community. Reproduction of *Bulletin* articles is permissible, with attribution. Neither the U.S. Government, CPIA, nor any person acting on their behalf, assumes any liability resulting from the use or publication of the information contained in this document, or warrants that such use or publication of the information contained in this document will be free from privately owned rights. The content of the *Bulletin* is approved for public release, and distribution is unlimited.

Paid commercial advertisements published in the *Bulletin* do not represent any endorsement by CPIA.

Melissa A. Mason Editor  
Sharon P. Counihan Layout Artist  
(410) 992-7307 ext. 217 Fax (410) 730-4969  
E-mail: [mam@jhu.edu](mailto:mam@jhu.edu)  
World Wide Web: <http://www.jhu.edu/~cpia/>

The Johns Hopkins University/CPIA  
10630 Little Patuxent Parkway, Suite 202  
Columbia, Maryland 21044-3204

Operating under Contract: SPO700-97-D-4004

# The *Bulletin* Board

The following are various meetings and events. We welcome all such announcements, so that the propulsion community can be better served with timely information. See back page for the JANNAF Calendar.

2000	Topic	Sponsor	Location
5/9-11	Cartridge Actuated Device and Propellant Actuated Device (CAD/PAD) Technical Exchange Workshop	NSWC	Waldorf, MD
5/10-12	AIAA Global Air and Space Conference and Exhibition	AIAA	Arlington, VA
6/19-22	Fifth International Symposium on Special Topics in Chemical Propulsion (5-ISICP): Combustion of Energetic Materials	Penn State Univ	Stresa, Italy
7/2-7	Gordon Research Conference on Energetic Materials	GRC	Tilton School, NH
7/16-19	36th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit	AIAA	Huntsville, AL
7/16-21	27th International Pyrotechnics Seminar	LANL	Grand Junction, CO
7/17-20	9th Annual AIAA/BMDO Technology Conference Exhibit	AIAA	San Diego, CA
7/18-20	DDESB 29th Explosives Safety Seminar	DDESB	New Orleans, LA
8/15-18	2nd International Hypersonic Wavrider Symposium	AIAA	Monterey, CA
9/18-20	Aerospace Materials, Processes, and Environmental Technology Conference	MSFC	Huntsville, AL
10/20-11/1	Space Business Conference and Exhibition	AIAA	San Jose, CA
11/7-10	AIAA 2000 Missile Sciences Conference	AIAA	Monterey, CA
2001	Topic	Sponsor	Location
1/8-11	39th AIAA Aerospace Sciences Meeting and Exhibition	AIAA	Reno, NV
4/TBD	42nd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference - AIAA/ASME/AHS Adaptive Structures Forum - AIAA Forum on Non-Deterministic Approaches	AIAA	TBD
7/6-14	37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit	AIAA	Salt Lake City, UT
11/6-8	18th Symposium on Explosives and Pyrotechnics	FAPF	Philadelphia, PA

**AIAA** = American Institute of Aeronautics and Astronautics (703) 264-7500, (800) 639-2422, or <http://www.aiaa.org>  
**DDESB** = U.S. Department of Defense Explosives Safety Board, Dorothy L. Becker (410) 992-7302, or [dlbecker@jhu.edu](mailto:dlbecker@jhu.edu)

**FAPF** = Franklin Applied Physics, Inc., James G. Stuart, Ph.D. (610) 666-6645

**GRC** = Gordon Research Conference, Richard Behrens (Sandia National Labs), (925) 294-2170, or fax: (925) 294-2276

**LANL** = Los Alamos National Lab, Alita Roach (505) 665-6277, or fax: (505) 665-3407

**MSFC** = Marshall Space Flight Center, Jodi Weiner (256) 533-5923, or [jweiner@aol.com](mailto:jweiner@aol.com)

**NSWC** = Naval Surface Warfare Center (Indian Head), Dave Brooks (301) 744-6705, or [brooksdh@ih.navy.mil](mailto:brooksdh@ih.navy.mil); Chris Nugent (301) 744-2355, or [nugentcm@ih.navy.mil](mailto:nugentcm@ih.navy.mil); Nancy Willett (301) 744-2300, or [willettnl@ih.navy.mil](mailto:willettnl@ih.navy.mil)

**Penn State Univ** = Professor Kenneth K. Kuo (814) 863-6270, or fax: (814) 863-3203

Mark your calendars now  
for the  
**29th United States  
Department of Defense  
Explosives Safety Seminar**  
to be held on 18-20 July 2000  
at the Sheraton Hotel in New  
Orleans, Louisiana. This seminar  
is the premier event in the world  
for prominent military,  
industry, and international  
experts from the explosives  
safety community. The  
preliminary program and  
invitation will be distributed  
in April 2000.

Further information about this  
meeting can be obtained at the  
following websites: <http://www.hqda.army.mil/ddesb/esb.html> or <http://www.jhu.edu/~cpia/> or by e-mail to [DDESBseminar@jhu.edu](mailto:DDESBseminar@jhu.edu).

See CPIA's Homepage  
"Calendar of Events" link  
(URL=<http://www.jhu.edu/~cpia/>)

Mark your calendars now  
for the  
**16 May 2000  
Information Analysis Center  
Business Meeting**  
to be held at  
Wright Patterson AFB, Ohio.

This meeting is sponsored by  
the Defense Technical  
Information Center and will  
feature high level invited  
speakers from Wright Patterson  
Air Force Base as well as  
other key agencies.

For further details, please contact  
Donna Egner at  
937-255-4840, or e-mail  
[degner@bah.com](mailto:degner@bah.com)

## JANNAF Meeting Reminders

**29th PDCS & 18th S&EPS Joint Meeting  
May 8-12, Cocoa Beach, FL**

**24th EPTS & 7th SPIRITS User Group Joint Meeting  
May 15-18, Nellis AFB, FL**

## The JHU Applied Physics Laboratory Continues...continued from page 1

of RBCC-specific operations and flowpath characteristics, using its high-speed wind tunnel test cells and long experience in similar dual-combustor ramjet/scramjet research. Laboratory-developed analytical tools have been applied to a subscale, axisymmetric RBCC configuration, to evaluate the engine's theoretical performance and to guide the test program. Tharen Rice of the RTDC is currently conducting tests to assess the effect of air augmentation on the operation at low Mach numbers in a heavyweight, heat-sink engine.

As part of the JHU/APL RTDC, the W. H. Avery Advanced Technology Development Laboratory (AATDL) maintains a hypersonic wind tunnel complex for investigation of aerospace technologies related to interceptor missiles, cruise missiles, space-access vehicles, and long-range high-speed aircraft. The AATDL was constructed in the early 1960's for investigations into the performance and operability of ramjet and scramjet engines. The AATDL facilities provide capabilities for aerothermal testing from Mach 4 to Mach 7, whereby various structures and materials can be exposed to high-speed flow environments at varying angles-of-attack and altitude conditions.

The aerothermal freejet wind tunnel in Test Cell 5 is capable of simulating the aerothermal environment up to Mach 8 and has been an integral part of the IR Dome development for STANDARD Missile for over a decade. The AATDL also provides direct-connect and free-jet testing of air-breathing engine components, and maintains the capability to design and fabricate wind-tunnel models.

The principal components of the AATDL facility, shown in Figure 1, include a high-pressure airfield, air distribution network, five test cells, and a two-stage steam ejection exhaust system for altitude simulation. Major subsystems include the delivery systems for oxygen, hydrogen, hydrocarbon fuel, and cooling water and the facility control and data acquisition systems. Flow rates for all gases are computer controlled using digital values enabling accurate single-point flow simulation as well as a variable-condition trajectory simulation. Test time for combustion tests can be set by different subsystems depending on the test requirement. To prepare for hypersonic engine testing being planned by DARPA and ONR, JHU/APL made a major capital investment in 1998 to refurbish the large-scale,

direct-connect scramjet combustor test all previously operational under the National Aerospace Plane Program. This test cell is capable of testing full-scale, tactical missile size combustors up to approximately Mach 8. The refurbished direct-connect combustor test cell (Test Cell 1) is shown in Figure 2 (on page 5) where a two-dimensional scramjet combustor is installed. In its current configuration, the airstream is brought online through a flexible bellows system to allow direct measurement of combustor thrust. A large scale calorimeter is used to determine combustion efficiency. The vitiated air system, supply nozzle, thrust stand, and combustor are shown in Figure 2. This test cell was recently used for DARPA Laser Ignition Studies and is currently being modified to test a full scale DCR combustor rig under the ONR HWT Program. Test Cell 2 is the freejet complement to Test Cell 1 with capability to test freejet rigs up to Mach 7 in a 15.2-inch diameter axisymmetric nozzle.

In addition to combustion testing, the AATDL maintains test capabilities for materials evaluation, electric power control, sensor window development, and assess-

*continued on page 5*

## PRO-TECH® Stabilizers Metal Deactivating Antioxidants Only From MACH I, Inc.

MACH I produces and markets the PRO-TECH® Stabilizer family of metal deactivating antioxidants. PRO-TECH Stabilizers were developed by aerospace chemists to ensure propellant pot life and suppress oxidative degradation of propellant binder polymers. PRO-TECH Stabilizers offer space-age technology advances to formulators of solid propellants.

### FEATURES:

- Recommended for HTPB/isocyanate propellants
- Especially effective with iron oxide and ferrocene catalysts
- Compatible with energetic ingredients and binders
- Stable in storage
- Safe to use

### BENEFITS:

- Dependable propellant pot life
- Increased storage stability
- Effective at 0.1% in propellant
- Replace ordinary antioxidants
- Greater formulation freedom
- Permit cure catalysis if desired



**Let Your Antioxidant Needs Reach MACH I**

340 East Church Road • King of Prussia, PA 19406

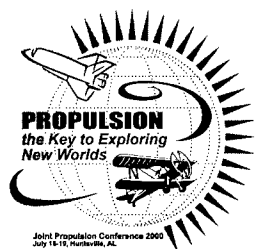
\*PRO-TECH is a registered trademark of United Technologies.

For more information and our brochure, Phone: 610-279-2340;  
Fax: 610-279-6605; E-mail: machi@machichemicals.com

# 36<sup>th</sup>

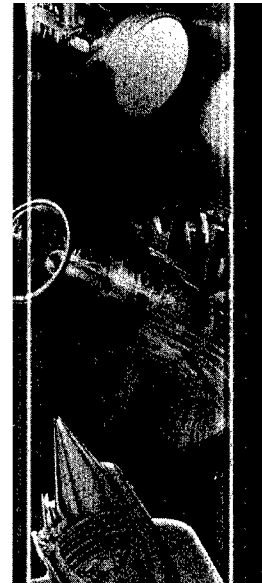
# AIAA/ASME/SAE/ASEE

## Joint Propulsion Conference & Exhibit



### 16-19 July 2000

Von Braun Civic Center • Huntsville, Alabama



## Propulsion—Key to Exploring New Worlds

Early Registration Deadline: 16 June 2000

### Technical Sessions

- Electric Propulsion
- Solid Rockets
- Future Flight Systems
- Launch Vehicles
- Hybrid Rockets
- Analysis and Component Technology
- Energetic Components and Systems
- Propellants and Combustion

*This is just a few of the technical sessions being featured at the Joint Propulsion Conference.*

*The completely searchable program is available at*

*<http://www2.aiaa.org/programs/joint00-search.cfm>.*

### AIAA Professional Development Short Courses

20-21 July 2000

#### Solid Rocket Propulsion Status & Evolution

Organized by  
AIAA Solid Rockets Technical Committee

#### Electric Propulsion For Space Systems

**Instructors:** Dr. Frank M. Curran, Dr. David King, Dr. Paul J. Wilbur, and Dr. L. Kevin Rudolph

#### Liquid Rocket Propulsion—Evolution and Advancements II

**Instructors:** Deborah Paul, Randy Parsley, Dr. Ray Moszee, Steve Bouley, Brian Winters, and Dr. Rob McAmis

#### Future Flight Propulsion: Advanced Concepts in Rocket Propulsion, Nuclear Systems, Advanced Physics, and High-Energy Density Propellants

**Instructors:** Bryan Palaszewski, Dr. Stanley Borowski, Dr. Robert H. Frisbee, Dr. Franklin B. Mead Jr., and Charles Garner

Register for one of these professional development courses and receive FREE admittance to the Joint Propulsion Conference and Exhibit. This special offer does not include the receptions, luncheons, papers, or any other ancillary or special conference functions. These items can be purchased separately.

*Complete information for each of these courses can be obtained from AIAA's Web site at [www.aiaa.org](http://www.aiaa.org) or by calling AIAA at 703/264-7500.*

### Meeting Information

#### Exhibits

The exhibits will feature organizations involved in liquid, solid, nuclear, electric, and other forms of propulsion for aerospace, as well as those involved in engine systems, environmental controls systems, ground support equipment, software, testing, analysis research and development, management, propellant tanks, thermal products, noise and vibration, and simulation components of this technology.

#### Exhibit Hours

Monday, 17 July . . . . .1000-1600 hrs  
Reception . . . . .1800-1930 hrs  
Tuesday, 18 July . . . . .1000-1600 hrs

### Register in advance and save \$50!

Conference participants are encouraged to use the registration form on the back of this page. Save \$50 off the regular rate when AIAA receives your registration with payment by 16 June 2000.

### Accommodations

AIAA has made arrangements for blocks of rooms at Huntsville area hotels. The housing form may be downloaded from the Web at [www.huntsville.org/jpc2000](http://www.huntsville.org/jpc2000). All reservations must be returned to the Huntsville CVB Housing Department by fax at 256/551-2324 or by mail at 700 Monroe Street, Huntsville, AL 35801. These rooms will be held for AIAA until 15 June 2000 and then released for use by the general public. A deposit equal to \$100 will be required to secure your reservations. Government Employees—There are a limited number of sleeping rooms available at the government hotel per diem at each property. Identification is required.

### Corporate Sponsors

- Aerojet
- Atlantic Research
- Boeing Rocketdyne
- CSC
- Lockheed Martin
- Sverdrup
- SNECMA
- Thiokol
- TRW
- Pratt & Whitney UTC



# 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit 16-19 July 2000 Von Braun Civic Center • Huntsville, Alabama

## REGISTRATION FORM

**All registrants please complete the information below.**

0414CP1A

**1**

Conference Badge Name	First/Given Name	M.I.	Last/Family Name
Organization Name/Division/Mailstop			
Address Line 2			
City	State	Country/ZIP/Postal Code	
E-mail Address		Daytime Phone Number	
Fax Number (include country code)		Job Title/Rank	

**3**

**AIAA MEMBERSHIP:** For those paying the full nonmember conference registration fee, sign below to receive your complimentary one-year AIAA membership. (Offer valid within six months of conference start date.) By completing this form, you acknowledge that AIAA needs the information requested here to provide you with the best possible service. From time to time, we make member and customer information available to companies whose products and services may be of interest to you. If you do not want your name and address exchanged, please check here: ☐

Signature \_\_\_\_\_ Date \_\_\_\_\_

Check here ☐ if you are renewing or reinstating your membership.  
(You must pay full nonmember conference fee.)

**4**

**RETURN FORM TO:** American Institute of Aeronautics and Astronautics  
Dept. #4260  
P.O. Box 85080  
Richmond, VA 23285-4260  
Fax: 703/264-7657

Registration forms must be received by **16 June 2000** to receive lower early bird rate. Registration forms **cannot** be processed without full payment.

Cancellations must be received in writing no later than **21 June 2000**. There is a \$50 cancellation fee. Registrants who cancel beyond this date or fail to attend will forfeit the entire fee. For questions, call 800/639-AIAA or 703/264-7500 (outside U.S.).

**5**

Check here if you need to make special arrangements due to a disability. Attach requirements on a separate sheet of paper. ☐

**6**

### FORM OF PAYMENT

AIAA Member No. \_\_\_\_\_

- |  |   |
|--|---|
| <input type="checkbox"/> Purchase Order  | <input type="checkbox"/> American Express |
| <input type="checkbox"/> Check           | <input type="checkbox"/> VISA             |
| <input type="checkbox"/> Travelers Check | <input type="checkbox"/> MasterCard       |
| <input type="checkbox"/> Wire Transfer   | <input type="checkbox"/> Diners Club      |

Credit Card Number:

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Expiration Date: \_\_\_\_\_ Month \_\_\_\_\_ Year

Signature \_\_\_\_\_

Please check the society to which you belong.

- |                               |                               |
|-------------------------------|-------------------------------|
| <input type="checkbox"/> AIAA | <input type="checkbox"/> ASME |
| <input type="checkbox"/> SAE  | <input type="checkbox"/> ASEE |

### FOR AIAA USE ONLY

Rec'd by \_\_\_\_\_

Date processed \_\_\_\_\_

Amount rec'd \_\_\_\_\_

**2**

Select your registration options below. Payment by check, credit card, or money order—payable to AIAA—must accompany registration. To pay the member rate, your membership must be in good standing.

### REGISTRATION OPTIONS

**Early Bird By 16 Jun 00 Late/On Site After 16 Jun 00**

Society Member	Non-Member	Society Member	Non-Member
----------------	------------	----------------	------------

#### OPTION 1: PROFESSIONAL DEVELOPMENT

Future Flight Propulsion: Advanced Concepts in Rocket Propulsion, Nuclear Systems, Advanced Physics, and High-Energy Density Propellants  
☐\$700 (A1) ☐\$800 (B1) ☐\$745 (C1) ☐\$845 (D1)  
 Solid Rocket Propulsion Status and Evolution  
☐\$705 (E1) ☐\$800 (F1) ☐\$745 (G1) ☐\$845 (H1)  
 Electric Propulsion for Space Systems  
☐\$700 (I1) ☐\$800 (J1) ☐\$745 (K1) ☐\$845 (L1)  
 Liquid Rocket Propulsion—Evolution and Advancements II  
☐\$755 (M1) ☐\$850 (N1) ☐\$795 (O1) ☐\$895 (P1)

Register for one of the above courses and attend the Joint Propulsion Conference and Exhibit for free. (Includes sessions, exhibits, and Monday exhibits reception only.)

#### OPTION 2: FULL CONFERENCE W/ LOOSE PAPERS

☐\$400 (A2) ☐\$525 (B2) ☐\$450 (C2) ☐\$575 (D2)  
 (Includes sessions, exhibit, Sunday evening reception, Monday boxed lunch, Monday exhibits reception, Tuesday awards luncheon, and one copy each of up to 10 papers.)

#### OPTION 3: FULL CONFERENCE W/CD-ROM (PC ONLY)

☐\$565 (A3) ☐\$690 (B3) ☐\$615 (C3) ☐\$740 (D3)  
 (Includes sessions, exhibit, Sunday evening reception, Monday boxed lunch, Monday exhibits reception, Tuesday awards luncheon, and conference CD-ROM.)

#### OPTION 4: FULL-TIME STUDENT

☐\$0 (A4) ☐\$25 (B4) ☐\$10 (C4) ☐\$35 (D4)  
 (Includes sessions, exhibits Sunday evening reception, and Monday exhibits reception only.)

#### OPTION 5: FULL-TIME RETIRED MEMBER

☐\$0 (A5) N/A ☐\$10 (B5) N/A  
 (Includes sessions, exhibits Sunday evening reception, and Monday exhibits reception only.)

#### OPTION 6: BLOCK (ADVANCE ONLY)

☐\$305 (A6) ☐\$305 (B6) N/A N/A  
 (One complete typed list plus individual registration forms for 10 or more persons from same organization. Includes sessions, exhibits Sunday evening reception, and Monday exhibits reception only.)

#### OPTION 7: TUESDAY EVENING OFFSITE EVENT HUNTSVILLE SPACE & ROCKET CENTER DINNER

☐\$5 (A7) No. of tickets \_\_\_\_\_ Tickets are limited, so sign up now!

### ACCOMPANYING PERSON:

Attending Monday's breakfast? ☐ Yes ☐ No

Name: \_\_\_\_\_

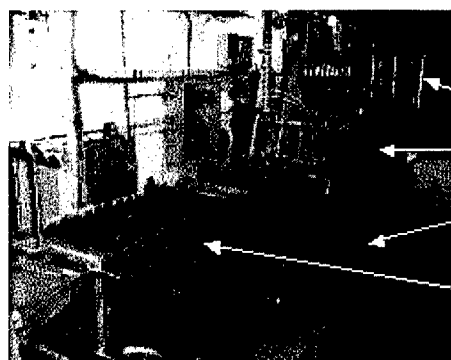
### EXTRA TICKETS

Monday Boxed Lunch ☐\$13 (T1) No. of tickets \_\_\_\_\_  
 Monday Exhibits Reception ☐\$22 (T2) No. of tickets \_\_\_\_\_  
 Tuesday Awards Luncheon ☐\$25 (T3) No. of tickets \_\_\_\_\_  
 Extra CD-ROM (PC only) ☐\$200 (T4) No. of copies \_\_\_\_\_

**TOTAL DUE: \$ \_\_\_\_\_**

**Early bird registration deadline: 16 JUNE 2000**

## The JHU Applied Physics Laboratory Continues...continued from page 4



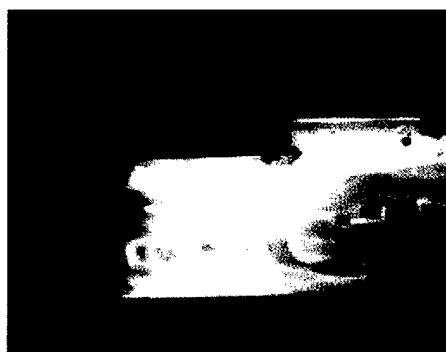
**Figure 2. Direct-Connect Scramjet Test Cell**

ment of advanced aerodynamic control techniques. As an example, the AATDL has developed facilities for investigating the control of supersonic flow using plasma aerodynamics techniques. An example is shown in Figure 3, which is a photograph taken from an experimental set-up that allows investigation of the effects of electrical discharges in supersonic flows. In this facility, the use of electric discharges for significantly modifying flows has been demonstrated.

After many years of using the AATDL test facilities solely for U.S. Government Programs, JHU/APL has established alli-

ances that enable industry to contract directly with the Laboratory for test services. The propulsion test facilities are made available under the Alliance for High-Speed Propulsion Testing and the aerothermal test capabilities are made available under the Alliance for High-Speed Aerothermal Sensor Testing.

While JHU/APL has maintained a strong research role in air-breathing engine work for missile propulsion for many years, it



**Figure 3. Mach 2.7 Flow Around Sphere with Upstream Electrical Discharge.**

has also engaged in the development of broader guided missile technologies since the mid 1940's. Consequently, the application of various non-air-breathing propulsion technologies has been a central part of many past and ongoing Laboratory projects, including the assessment of conventional and alternative propulsion technologies. In its role as a systems engineer, JHU/APL assesses the impact of competing propulsion technologies on system performance, operability, and functionality. The Lab may conduct experimental investigations of propulsion elements or applications, to provide a basis for these assessments.

As an example, hybrid rocket propulsion is a technology of potential interest for a number of applications where thrust magnitude control is desirable, along with the simplicity and relatively high performance of a solid rocket motor. To evaluate the potential of this technology, Harry Hoffman and Dan Simon are engaged in fundamental studies of conventional hybrid rockets to evaluate hybrid-unique phenomena. Facilities include a thrust

*continued on page 6*



## TDK 99™ SHIPPING NOW

The JANNAF Standard for Liquid Engine  
Performance Prediction Just Got Better

The TDK 99™ code uses the JANNAF methodology plus enhancements to compute thrust chamber performance.

### FEATURES:

- Planar or Axially Symmetric Flow
- Transpiration or Tangential Mass Injection
- Pitot Tube Option
- Dual Bell Option
- Scarfed, Plug, and Scramjet Nozzle Configurations
- Accepts High Temperature NASA Thermodynamic Data
- Increased Number of Kinetic Species and Reactions
- Nozzle Contour Optimization Routine with Kinetics, Boundary Layer, and Regen Effects
- Linkage to TECPLOT™
- Equilibrium Radiation Heat Transfer
- Linkage to SPF 2 or SPF 3
- Summary Output Files for Each Module
- Upper and Lower Wall Simulation
- New Algorithms for improved accuracy and robustness
- Electron Charge Balance Calculation for Improved Ions Analysis
- Treats Internal/External Flow Interaction (Plug Nozzle) along with a Base Pressure Correlation

**Improved Usability      Graphics Post Processor**  
**Runs on PC's under Win 95/98 & Win/NT**

**Available only from SEA, Inc. at just \$7995 for a single user license**  
Special Upgrade Offers Available to Current Owners of TDK 97™

For more information: **Software & Engineering Associates, Inc., 1802 N. Carson Street, Suite 200, Carson City, NV 89701-1230**  
contact: email: [info@seainc.com](mailto:info@seainc.com) Telephone: (775) 882-1966 FAX: (775) 882-1827

Visit our website at: <http://www.seainc.com>

Copyrighted by SEA, Inc. 2000 • All Rights Reserved.

## The JHU Applied Physics Laboratory Continues...continued from page 5

stand with a mass-flow-controlled reactant (fuel or oxidizer) injector, and instrumentation to closely monitor the flow conditions at various points in the operation to permit complete control and evaluation of the unit operation. Goals of the project include careful evaluation of basic phenomena and underlying mechanisms involved in transients (ignition rise, thrust tail-off, throttling), and predictability of recession.

Finally, as an adjunct to its technology work relating to vehicle performance and systems engineering, JHU/APL has developed approaches to detection and assessment of energetic material aging. Dr. Lawrence Hunter has developed an experi-

mental method for detecting chemical aging of energetic (propellant) materials, along with the necessary chemical aging models that form the theoretical basis for the technique. The method has been experimentally evaluated; remaining life is predicted using chemical aging models developed for the particular material formulation. The method appears to be applicable to a wide range of chemical aging situations.

Other recent JHU/APL propulsion-related projects and initiatives include the investigation of lasers to ignite or pilot mixed gaseous fuels and oxidizers (part of a DARPA-funded effort in 1998), microsatellite propulsion, high temperature

materials, light-gas-gun launch systems, and advanced "smart" composite structural materials.

The JHU/APL is poised to continue its role as a developer, and evaluator, and a user of propulsion technology in the new century with its ongoing research and technology development, and systems engineering efforts. JHU/APL will continue to evaluate and apply technology advancements to further the capabilities of systems of national importance.

For further information please contact Mr. Harry Hoffman at (443) 778-8870, or e-mail: [harry.hoffman@jhuapl.edu](mailto:harry.hoffman@jhuapl.edu).

### **FIREX™**

#### **Ablative and Intumescent Protection Coatings**

##### **APPLICATIONS**

- PROTECTION FROM AERODYNAMIC HEATING IN HYPER VELOCITY APPLICATIONS AND LAUNCH VEHICLES.
- FIRE PROTECTION FOR ROCKET MOTORS, ROCKET & MISSILE LAUNCHERS, STORAGE AREAS & SHELTERS.
- FIREX CAN OFFER FIRE PROTECTION FOR COMMUNICATIONS AND COMMAND CENTERS.
- THERMAL PULSE PROTECTION.

**FIREX™** WAS DEVELOPED IN RESPONSE TO THE U.S. NAVY'S COOK-OFF IMPROVEMENT PROGRAM AFTER THE CATASTROPHIC FIRES ON THE USS FORESTAL IN 1967 AND THE USS ENTERPRISE IN 1969.



##### **PRODUCTS**

- **RX-2390 & RX-2390NS**, two part epoxy resin systems. **RX-2390NS** is without solvents.
- **RX-2373**, a two part epoxy system without solvents.
- **RX-2376**, a two-part urethane resin system.
- **FIREX™** can be applied by spray, trowel, cast, or molded. Tape and sheet versions available.

**MINTEQ® INTERNATIONAL INC.**  
Subsidiary of **MINERALS TECHNOLOGIES INC.**

**PYROGENICS GROUP**  
640 NORTH 13TH STREET  
EASTON, PA 18042

1-800-962-8586 FAX 610-250-3325

[www.mineralstech.com](http://www.mineralstech.com)

### **PYROID® PYROLYTIC GRAPHITE**

##### **APPLICATIONS**

- ROCKET NOZZLE INSERTS
- ION GRIDS
- EXCEPTIONAL THERMAL MANAGEMENT MATERIAL
- HIGH PURITY, < 5 ppm TOTAL ASH

**PYROLYTIC GRAPHITE** performs well at high temperatures, with an Oxidation Threshold of 650°C.

**OVER 30 YEARS OF EXPERIENCE IN  
PYROLYTIC GRAPHITE & CARBON MATERIALS**

**ALL GRAPHITES ARE NOT CREATED EQUAL!**



##### **FACILITIES**

- PYROLYTIC GRAPHITE MANUFACTURE
- CNC MACHINING
- CVI & CVD OF CARBON COMPOSITES
- CUSTOM HIGH TEMPERATURE VACUUM HEAT CLEANING

**MINTEQ® INTERNATIONAL INC.**  
Subsidiary of **MINERALS TECHNOLOGIES INC.**

**PYROGENICS GROUP**  
640 NORTH 13TH STREET  
EASTON, PA 18042

1-800-962-8586 FAX 610-250-3325

[www.mineralstech.com/products&markets](http://www.mineralstech.com/products&markets)



## Low Cost Ablative, Insulating, Structural and Adhesive Materials for Aerospace Applications

Lockheed Martin Naval Electronics & Surveillance Systems (*LM NE&SS-Baltimore*) is seeking sources for low cost, high performance materials for use in high temperature gas management subsystems. Technical performance requirements for the various technologies of interest are described in the following paragraphs.

**1) High Temperature Structural Ablative System:** Materials are required to withstand heat fluxes up to 900 BTU / ft<sup>2</sup>-sec for up to 10 seconds. Gas temperature is 3500F. The material or system should be compatible with box and tubular shaped form factors. Average density not to exceed 200 lbs / ft<sup>3</sup>. Thin tube thickness is needed, so high strength materials are required.

**2) Low Cost, High Temperature Ablative Materials:** Materials are required to withstand heat fluxes up to 1600 BTU / ft<sup>2</sup>-sec for up to 10 seconds. Gas temperatures are as high as 6000F. Acceptable materials must be able to protect structural components from excessive heating and erosion. Density not to exceed 200 lbs / ft<sup>3</sup>. Low thermal conductivity is desired, and shall be a maximum of 65 BTU/ hr/ ft<sup>2</sup>/F/ft. The material should have a failure strain greater than 0.14%. High temperature and room temperature cure materials will be considered.

**3) Low Cost, High Temperature Adhesive Materials:** New adhesive materials are needed to bond metals to composites and require a minimum shear strength of 350 psi at 300F. Primary factors for adhesives will be low cost and high strength at elevated temperature. The adhesive should be a thick paste capable to form a .030" - .150" bond line. Room temperature cure adhesive is desirable.

**4) Low Cost, High Temperature Insulating Materials for Low Heat Flux Environments:** Materials will operate in low heat flux environments of 75 BTU/ ft<sup>2</sup>-sec. Less than 1 BTU/ hr/ ft<sup>2</sup>/F/ft thermal conductivity is required. Spray, brush or trowel application is desirable. No material strength is required, but the material should remain attached to the metal while subjected to high subsonic hot gasses.

**5) Low Cost, High Temperature Insulating Materials for High Heat Flux Environments:** Materials are required to withstand heat fluxes up to 1200 BTU / ft<sup>2</sup>-sec for up to 1.7 minutes. Gas temperature is 3500F. Less than 1 BTU/ hr/ ft<sup>2</sup>/F/ft thermal conductivity is required. Spray, brush or trowel application is desirable. Surfaces will be flat, steel plates. No material strength is required, but the material should remain attached to the metal while subjected to high subsonic hot gasses.

Interested contractors should respond by May 31, 2000. Responses to be sent to Lockheed Martin NE&SS-Baltimore, 2323 Eastern Boulevard, Baltimore MD 21220-4207, Attention: David Luksik, M/S 800W.

### Responses should include the following information:

1. Description of recommended materials/technology.
2. Description of current application or development of the subject materials/technology.
3. Materials properties test data.
4. Description of manufacturing process required for material fabrication.
5. Materials cost (per pound, per square foot of thickness).
6. Contractors are strongly encouraged to submit responses addressing low cost approach in material selection and fabrication.
7. Contractor credentials demonstrating previous experience in designing and developing material in specified area, including key technical personnel and in-house production facilities.

This solicitation should not be construed as a commitment or authorization to incur costs in anticipation of a resultant contract. Information provided herein is subject to modification and in no way binds Lockheed Martin to award a contract.



# **CPIA Bulletin**

Johns Hopkins University/Chemical Propulsion Information Agency  
10630 Little Patuxent Parkway, Suite 202  
Columbia, MD 21044-3204  
Phone (410) 992-7300

U.S. POSTAGE  
**PAID**  
COLUMBIA, MARYLAND  
PERMIT No. 425  
NONPROFIT ORGANIZATION

## **Official Business**

**ADDRESS CORRECTION REQUESTED**

Library  
Defense Technical Information Center  
8725 John J Kingman Rd  
DTIC-OCF  
Fort Belvoir VA 22060-6217  
|||||

### **JANNAF MEETING CALENDAR**

<b>2000</b>	<b>Meeting</b>	<b>Type</b>	<b>Location</b>	<b>Abstract Deadline</b>	<b>Paper Deadline</b>
<b>May 8-12</b>	29th Propellant Development Characterization Subcommittee and 18th Safety and Environmental Protection Subcommittee Joint Meeting	Conference/ Workshop	Cocoa Beach, FL	Past	Past
<b>May 15-18</b>	24th Exhaust Plume Technology Subcommittee and 7th SPIRITS User Group Joint Meeting	Conference	Nellis AFB, NV	Past	Past
<b>Nov. 13-17</b>	37th Combustion Subcommittee, 25th Airbreathing Propulsion Subcommittee, 19th Propulsion Systems Hazards Subcommittee, 1st Modeling and Simulation Subcommittee Joint Meeting	Conference/ Workshop	Monterey, CA	May 15	Oct. 23
<b>2001</b>	<b>Meeting</b>	<b>Type</b>	<b>Location</b>	<b>Abstract Deadline</b>	<b>Paper Deadline</b>
<b>Mar. 26-30</b>	12th Nondestructive Evaluation Subcommittee, 21st Rocket Nozzle Technology Subcommittee and 34th Structures and Mechanical Behavior Subcommittee Joint Meeting	Conference/ Workshop	Cocoa Beach, FL	TBA	TBA
<b>July 11-13</b>	50th JANNAF Propulsion Meeting	Conference	Salt Lake City, UT	TBA	TBA

Attendance at JANNAF Conferences and Workshops is by invitation only.

MEETING CALENDAR SUBJECT TO CHANGE. FOR LATEST DETAILS, CONTACT CPIA AT (410) 992-7304.

*Printed on recycled paper*